Nanotechnology

Fighting fungal growth with silver

Back in the Middle Ages, placing a silver coin on the tongue was said to ward off the plague. Today the precious metal acts against many different kinds of germs in a much smaller form: Nanoparticles of silver in wall paint prevent the formation of molds inside buildings and the growth of algae on outside walls.

A touch of silver

Researchers at the Fraunhofer Institute for Manufacturing Engineering and Applied Materials Research IFAM in Bremen are placing their hopes on the antibacterial effect of nanosilver. They have spent more than ten years developing processes for manufacturing the nanoparticles and tailoring them to a wide range of applications. The production of finest silver powder has already been successfully spun off, and is now one of the mainstay products of Bio-Gate Bioinnovative Materials GmbH. The IFAM is now focusing on processes for manufacturing silver colloids and thin films of silver on a nano scale. "Our aim is always to use the same process for both synthesizing the nanoparticles and integrating them in an essential component of the ultimate product," says Bernd Günther of the IFAM. To do this, the researchers refine the silver for colloidal solutions directly from the gas phase, using carrier liquids. The latter may then constitute an ingredient of a bactericide plastic material designed for medical applications, or it may be used as an additive in lubricants or sealants to prevent microbial contamination of machine tools. The researchers are currently developing printing techniques for argentiferous inks that will allow in-situ printing of predefined silver structures, for instance to be used in biochips.

Researchers at the Fraunhofer Institute for Biomedical Engineering IBMT in St. Ingbert are exploring another possible application for the nanoscale silver balls. Their aim is to use the tiny particles in cancer therapy.

Delicate mauve hairs nestle against one another, bending gently under the weight of the globular capsules at their tips. Burgeoning right next to them is a web of palest green, blending gradually into a billowing sea of silky black stems. A magic forest, full of delights. But not everywhere does the sight cause such enchantment. While the splendid array of fungi is fascinating to behold under a microscope, the hairy growths are a most unwelcome sight on walls and ceilings – and are moreover suspected of causing allergies and respiratory complaints. Nevertheless, they are not uncommon: a representative study conducted by the universities of Jena, Berlin and Dresden in 2003 shows that fungi proliferate in over nine percent of German dwellings.

The quickest way to combat the undesirable growths is usually to apply anti-fungal paint or a fungicide spray. The drawback to these products is that they are frequently based on biocides, which they gradually release into the environment. This means that the active substances not only penetrate to the root of the fungus, but also enter the human body, for instance by being inhaled. In addition, the biocide is gradually used up, detracting from the effectiveness of the coating as time goes by. An emission-free

alternative to these biocide-based coatings has been on the market since September. The product was developed by researchers at the Fraunhofer Institute for Chemical Technology ICT in Pfinztal, in collaboration with Bioni CS GmbH in Oberhausen. It works on the basis of noble particles – nanoparticles made of silver.

"Even in the Middle Ages healers knew that silver acts as a biocide," says Helmut Schmid of the ICT. "Modern medicine confirms that. So now we have used modern techniques to implement this knowledge, and integrated nanoparticles of the precious metal in wall paint." Trapped in the paint, the silver acts against fungi and bacteria like a contact poison. The effect is due to tiny quantities of silver ions released by the nanosilver. If these come into contact with the unwanted microorganisms, they

Growth of algae produces green stains on the outside walls of buildings.
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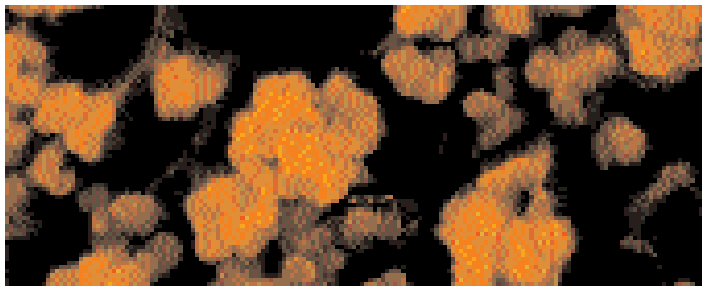
immediately attack on several fronts: They block enzymes that transport nutrients, destroy structure-forming proteins, bond with genetic material and interfere with biochemical processes of cell wall synthesis. Even very tiny concentrations of silver are enough to achieve this biocide effect. "The nanoparticles have such a large surface area relative to their volume that a ratio of



SEM image of silver nanoparticles.
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less than one gram of silver to ten kilograms of paint is enough to kill germs," says Schmid. These small quantities affect neither the appearance nor the coating properties of the paint.

Restraining nanosilver

Manufacturing the tiny particles and ensuring that they stay so small is a big challenge, however. The nanoparticles produced by the researchers in the liquid phase measure just thirteen millionths of a millimeter on average. Particles at this small size possess a very high surface energy, which they strive to reduce by congregating into larger agglomerates. "We prevent that from happening by stabilizing them with additives and immediately integrating them in a polymer system," says Schmid. The polymers have the added advantage of facilitating the admixture and homogeneous distribution of the silver particles in the paint suspension. And they have another effect, too: "By using the polymers we are restraining the nanosilver on a leash, so to speak, ensuring that it cannot escape from the paint," explains Schmid. "That's essential from a toxicological point of view, as medical researchers have not yet determined the precise extent to which indiscriminately released nanoparticles affect human health."

To verify that their paint is truly harmless, the manufacturers had it tested by TÜV Rheinland. "The requirements for their seal of approval are more stringent than for the 'Blue Angel', for example," states Bioni managing director Sven Knoll. The awarded signet is an official confirmation that the paint is non-toxic and will not cause cancer, deformities or mutations. Bioni has also developed an argentiferous paint formula for outside walls and had that officially tested, too – although in this case it was the efficacy of the paint that was tested. "It is becoming increasingly common to see green algae growing on the outside walls of buildings, which is to some extent due to improved thermal insulation," says Knoll. "Until now, the standard treatment was to apply fungicides." The fact that the argentiferous paint provides equally effective protection against the growth of algae has been documented in a test report issued by the Bremen Institute for Materials Testing.

Yet despite all its advantages, the argentiferous paint – whether used indoors or outdoors – has a significant drawback: It costs almost twice as much as the paint that do-it-yourselfers will find on the shelves of their local home improvement stores. "That's why we market our products directly instead of distributing them through retailers," says Knoll. This is the only way that the company can explain to customers the various functional aspects that justify the price. For instance, in addition to silver particles the paints contain a combination of binder and filler material holding tiny hollow balls of glass. "This makes our exterior paint act like Gore-Tex," Knoll explains. "The paint prevents the majority of water droplets from permeating the brickwork, but still allows water vapor to escape in the form of individual molecules." The formula also enhances the thermal resistance and durability of the paint, says Knoll: "It makes the paint extremely resistant to abrasion and chemical treatment, such as with disinfectants."

Particularly the last two aspects, in conjunction with the broad biocidal effect of the nanosilver, open up further market potential. "Last month we started promoting the paint in hospitals and clinics, and met with a very positive response," reports Knoll, who has already received the first orders for the product. Because silver interferes with various stages of cell metabolism, it can destroy a wide range of germs and make it difficult for microbes to develop resistance. "It even defeats the dreaded hospital bug Staphylococcus aureus," says Schmid. The danger posed by this pathogen has increased over the past few years, as about 20 percent of germs are resistant to conventional antibiotics. In contrast, less than one percent of the staphylococci survive direct contact with the Bioni paint. A new set of tests now starting will investigate the effect on other hospital bugs.

Barbara Schunk